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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Signed J Evens.

Dated 24 August 2004

[redacted]ents Form 1/77

Patents Act 1977
(Rule 16)

29 MAY 2004

THE PATENT OFFICE
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29 MAY 2004
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NEWPORT

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference ~~FLEXIBLE ADD DROP MULTIPLEXER MODULE~~ PF46

2. Patent application number *(The Patent Office will fill this part in)* 0412157.0

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

POLATIS LIMITED
332/2 CAMBRIDGE SCIENCE PARK
MILTON ROAD
CAMBRIDGE

Patents ADP number *(if you know it)* 08879694001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention FLEXIBLE ADD DROP MULTIPLEXER MODULE

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

IP21 Ltd
Norwich Research Park
Colney, Norwich, NR4 7UT

Patents ADP number *(if you know it)* 08294613001

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)

Number of earlier UK application	Date of filing *(day / month / year)*

8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request? YES

Answer YES if:

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.

Otherwise answer NO (See note d)

Patents Form 1/77

9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	
Description	2 ✓ in
Claim(s)	0
Abstract	0 (Included as 1st Para Description)
Drawing(s)	3 ✓

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	
Request for a preliminary examination and search (Patents Form 9/77)	
Request for a substantive examination (Patents Form 10/77)	
Any other documents (please specify)	Abstract included on page one of description

11. I/We request the grant of a patent on the basis of this application.

Signature(s) A Dames Date 28 May 2004

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

ANDREW DAMES 07855 210925
andrewdames@[redacted]polaris.com

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered YES in part 8, a Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7 you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.

Flexible Add/drop multiplexer module

Polatis 28 May 2004

Abstract:

A multi frequency channel blocker/attenuator using piezo actuators, and an enhancement to enable add /dropping of individual wavelengths directly to transponders.

Prior art: devices that spread light from a fibre into different frequency components via a diffraction grating, modulate the intensity of each component using either a LCD array or a linear array of tilting mirror elements, re-image the spectrum back off the diffraction grating into another fibre. (Lucent , ECOC 2002, Dr Roland Ryf), (Corning "Pure path" blocker)

Blocker attenuators made in this manner need several other active optical elements to make a complete flexible add drop multiplexer equipment, as they either just block beams, or form a 1 by 2 or two by two switch for each wavelength(ref Network Photonics) they still need a separate filter for each detector, which needs to be tunable for a fully flexible system.

What we describe here is a system where each add drop channel is individually scanned across the wavelengths spread out from the grating. Thus for example a complete 4 channel add/ drop unit can be made with only 4 moveable elements, providing all functions of detector channel filtering, through channel blocking, and frequency tuned coupling for the add laser in a single module.

The overall layout of the spectrometer is shown in fig 3, in and out collimators 3 and 4, collimator mirror 6 (plane, to keep collimators out of the way of their own beams), imaging mirror 7 (focal length = distance to grating), grating 5 – low PDL type, frequency plane reflective element 1 (which has 3 reflective surfaces: one perpendicular to axes of beams at that point and two at 45° to this surface). At mirror 1, to switch the light from the in / out ports to a pair of add drop ports, the light is shifted up or down by one collimator pitch to couple with a different pair of collimators eg add1/drop1 (10,11), add2/drop2 (12/13), add3 drop3(14,15) or add4/ drop4 (16,17) stacked vertically above and below 3 and 4.

This is done by a set of prisms (2, 21,22,23), one for each pair of add/drop ports, which translate the light beams periscope fashion (see figs 1 and 2), and the two side reflectors in the prism based mirror 1. Each prism is independently swung across the face off mirror 1 by the actuating mechanism to select the desired frequency to be added or dropped to that particular pair of ports. A key advantage of using the prisms to displace the light is that any tilt, twist, or small displacement up/down or in/out has no first order effect on the shifted beam at all. This makes the least demand on the actuation structure, which can be optimised for cost, and ruggedness.

Alternatively the prisms may be replaced by a 1D actuator array (9) causing objects (or the actuators themselves) to be inserted into the beams at each wavelength by a

variable amount. This results in a simple blocker architecture with one input, one output and variable attenuation for each wavelength. In this version the reflective element (1) may be replaced by a simple plane mirror (8).

Actuation is implemented with an enlarged piezo (40) and flexure set (43,44) as per GB 0312780, piezos as per GB 2378573. Sensing and control is done via capacitive sensing about the swing arms (41), feeding 2D position to the electronic controller as in GB 2372834. (all references are Polatis technology)

Specific embodiment

Blocker / attenuator.

Fig 4. 900 line /mm grating, 8 x 12 mm, at 45 degrees to incoming beam. Collimators 1mm diameter, 100 mm working distance. Band spacing 500GHz, 8 bands across C band, centred at 1550 nm. Distance between grating5, mirror 1 and the focussing lens 7 is 200mm, 200mm focal length. Pitch of frequency bands on mirror 1 is 1mm, total width 8mm. Beam waist of collimators ~ 350 um diameter, same as spot size on mirror. Angular separation between in and out collimator beams is 15 mrad. (separation between collimator centre lines is 1.5 mm) .

Blocking comb (9) is a piezo bimorph comb, tines 20 mm long, 1 mm pitch, 0.1 mm slots between tines, made of two layers of soft piezo ceramic each 0.25mm thick.. This is driven in parallel mode with a drive voltage swing of 300V, giving a deflection of 0.7 mm at the end of the piezo. The ends of the piezo are within 1mm of the mirror, mounted at an angle of 15 degrees to the horizontal. Arranged so that the end of the piezo moves from 0.25 mm (zero attenuation state) below beam centre to 0.45 mm above (fully blocked state).

Performance: loss < 3db open, >50db blocked.

Enhancement:
Addition of ¼ wave plate (31)to front face of mirror, axis aligned at 45 degrees to horizontal. This rotates the axis of polaristion 90 degrees between the two passages over the attenuating tines (the light passes through the waveplate twice), cancelling to first order the polaristion dependant loss created by the tines in the semi blocked state, and also cancelling to first order PDL introduced by the grating.

Further embodiment, incorporating the flexible add drop capability

Instead of the blocking comb, a set of four piezo driven swing arms move prisms across mirror 1. These are 1mm x 1mm, and displace the beam up or down by 1.3mm or 2.6mm to the four pairs of add drop ports. Arms (41) driven by 2D piezo (40) through pair of flexures (43,44). See fig. 1

The two functions (of flexible add drop and variable attenuation) can be combined in the same unit,(fig 5) by making all the prism displacements in the same direction, and placing the attenuating fingers (9) in front.

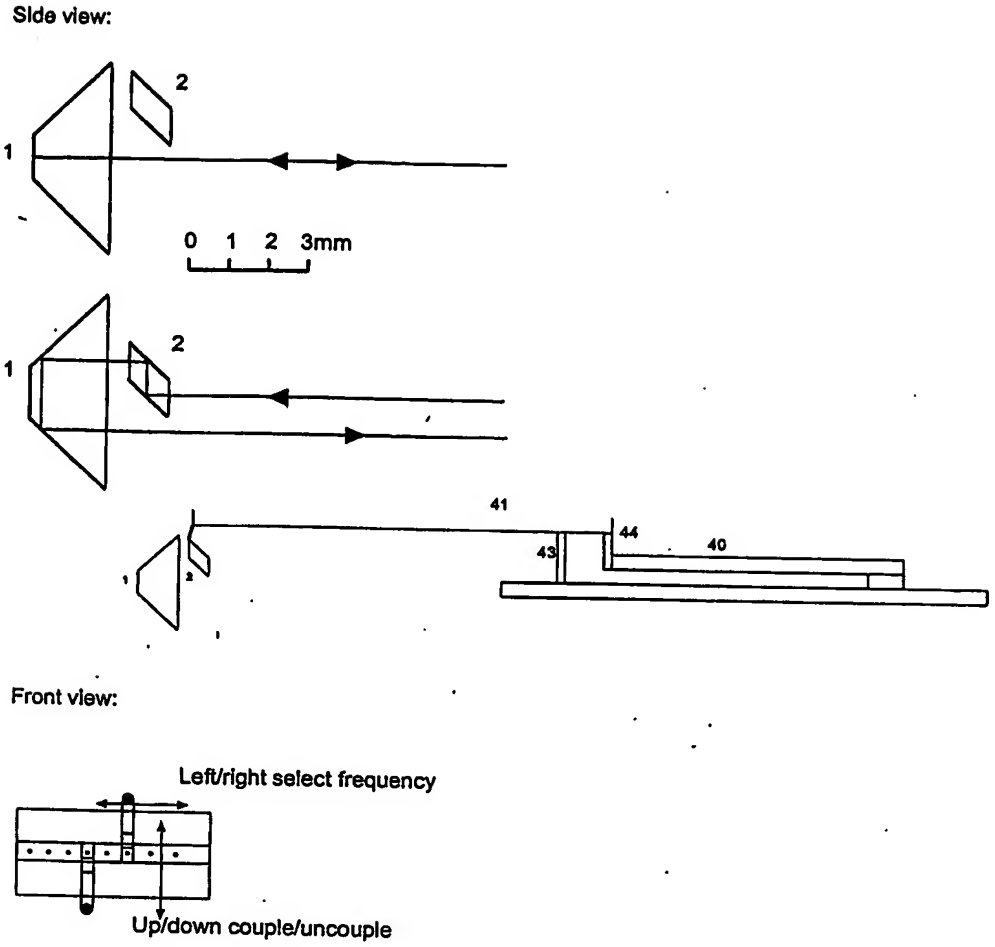

Side view:
2
1
0 1 2 3mm
2
1
41
44
43
40
Front view:
Left/right select frequency
Up/down couple/uncouple

Fig. 1

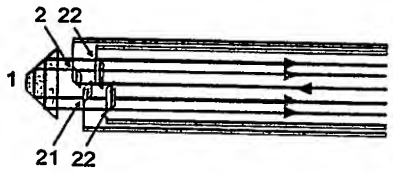

2 22
1
21 22

Fig. 2

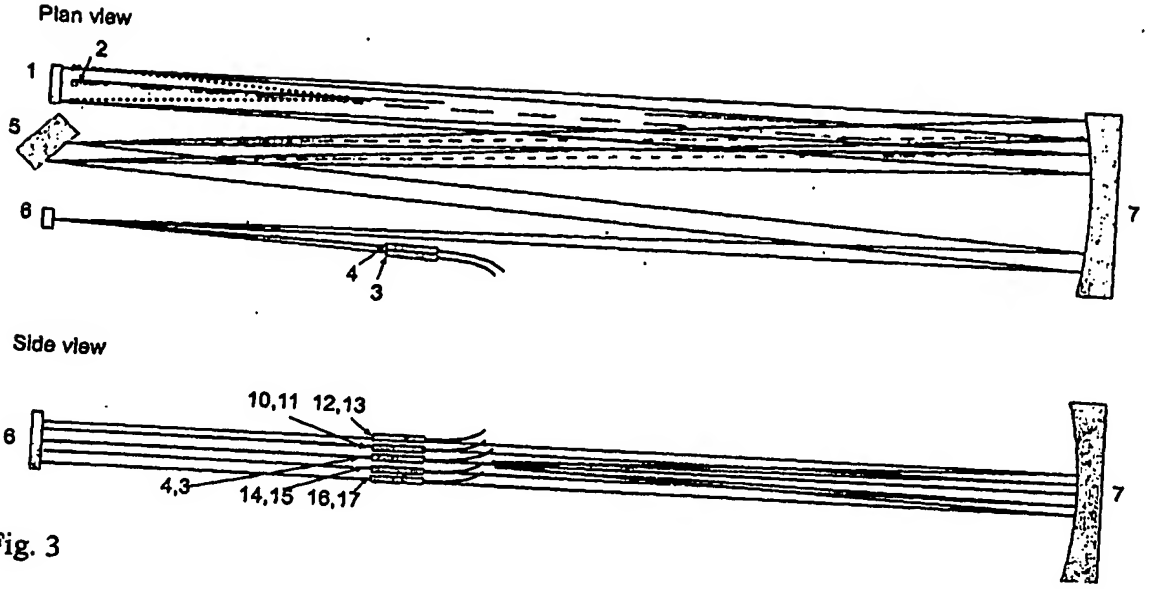

Plan view
1
2
5
6
7
4
3
Side view
6
10,11
12,13
4,3
14,15
16,17
7

Fig. 3

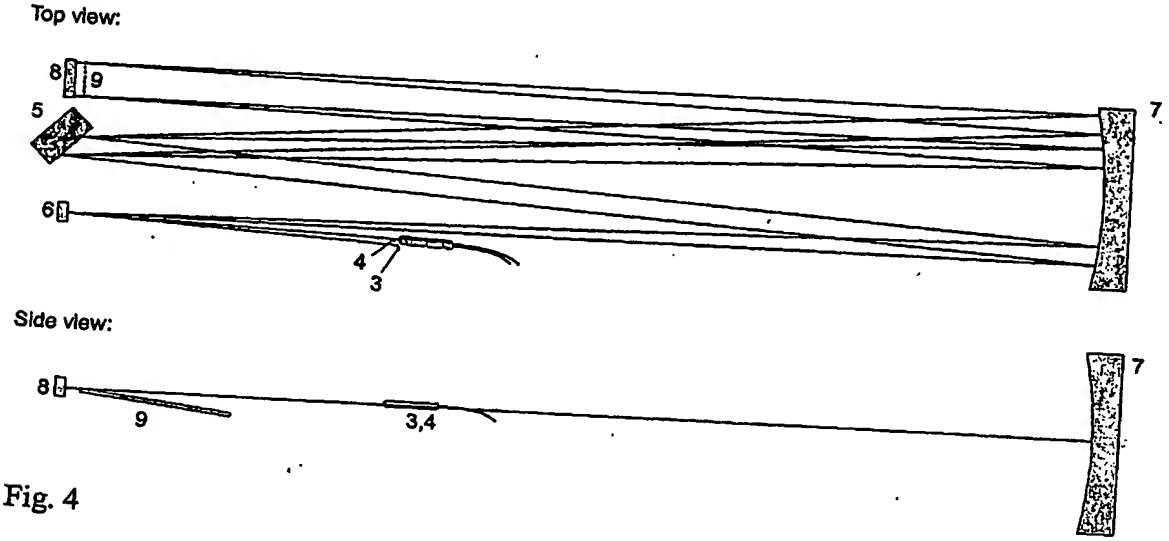
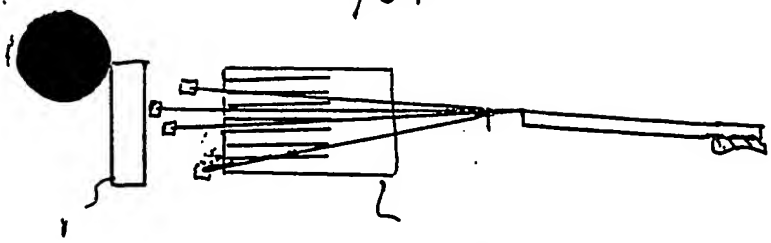

Top view:
8
9
5
7
6
4
3
Side view:
8
7
9
3,4

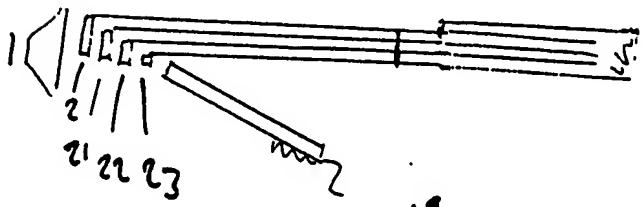
Fig. 4

TOP



9

SIDE



9

Fig 5.